Trace the Denmark Strait overflow water in an eddy-resolving Atlantic simulation: some preliminary results

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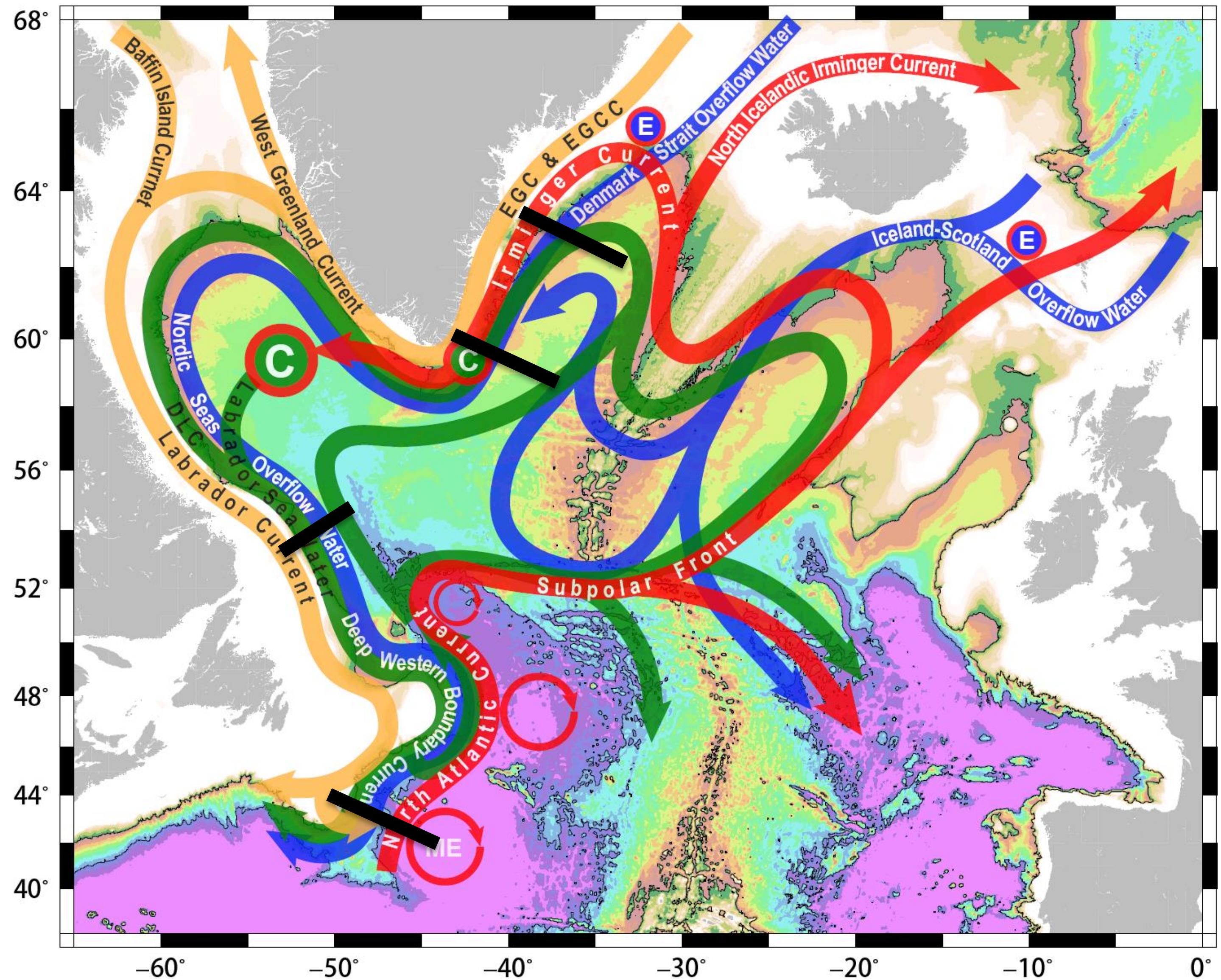
Motivation

- Passive tracer, when tagged to a particular water mass, can be used to “effectively” track the movement/circulation of the water mass and its interaction with the ambient water.

- When the Denmark Strait overflow water (DSOW) flow into the Irminger and Labrador Seas, the observed vertical structure of horizontal velocity shows a strong bottom intensification, typically not in general circulation models. We want to use tracer to quantify the associated mixing and water mass transformation.

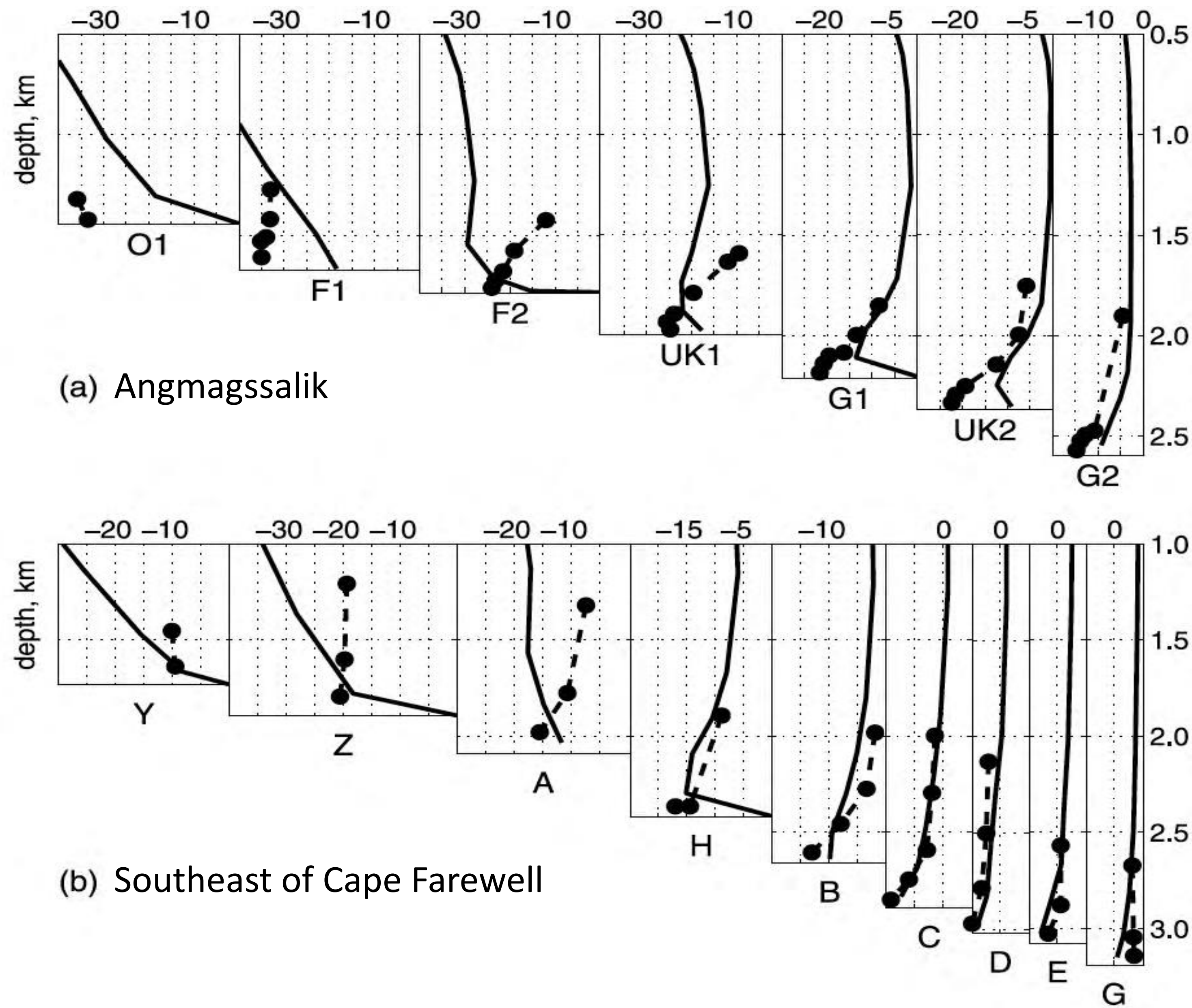
- Tracers (CFC, Oxygen, I^{129}, etc) have been widely used in observations associated with the DSOW, e.g., Smith et al., 2005. Can models simulate those tracer signature?

3-layer circulation in the SPNA

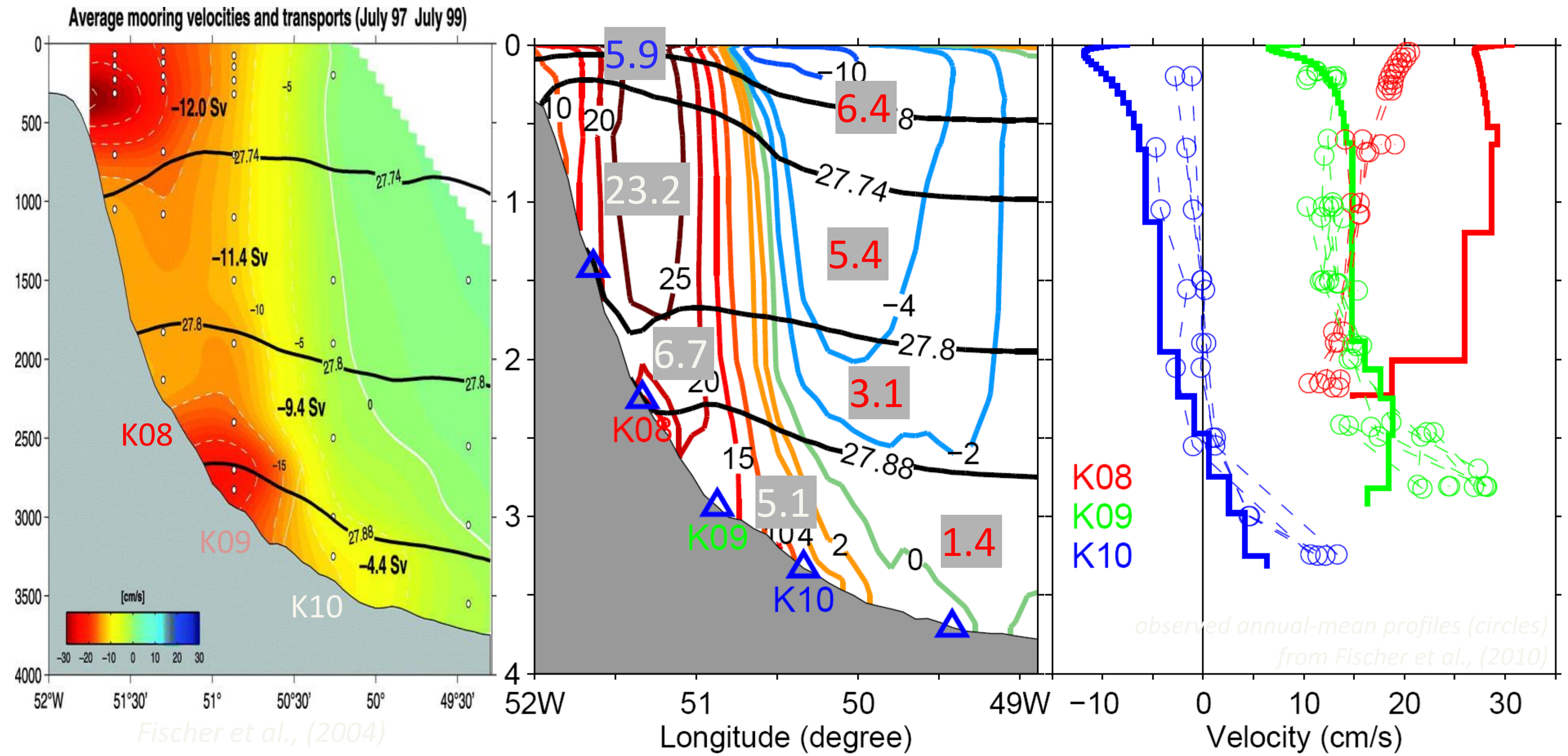


upper layer: Red and yellow ("modified" North Atlantic Water); middle layer: green (Labrador Sea Water); deep layer: blue (Nordic Seas Overflow Water)

Overflow structure in HYCOM vs. obs.

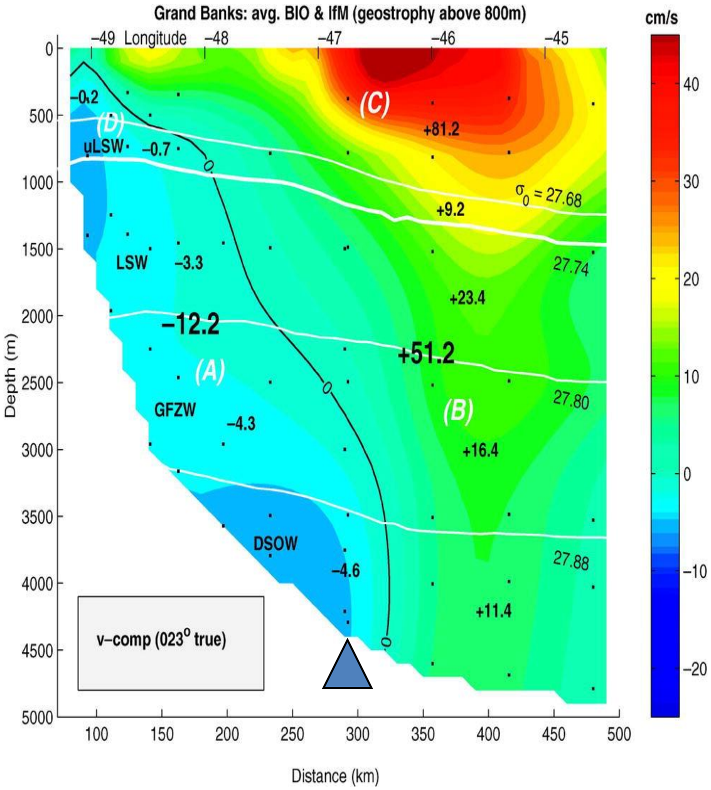


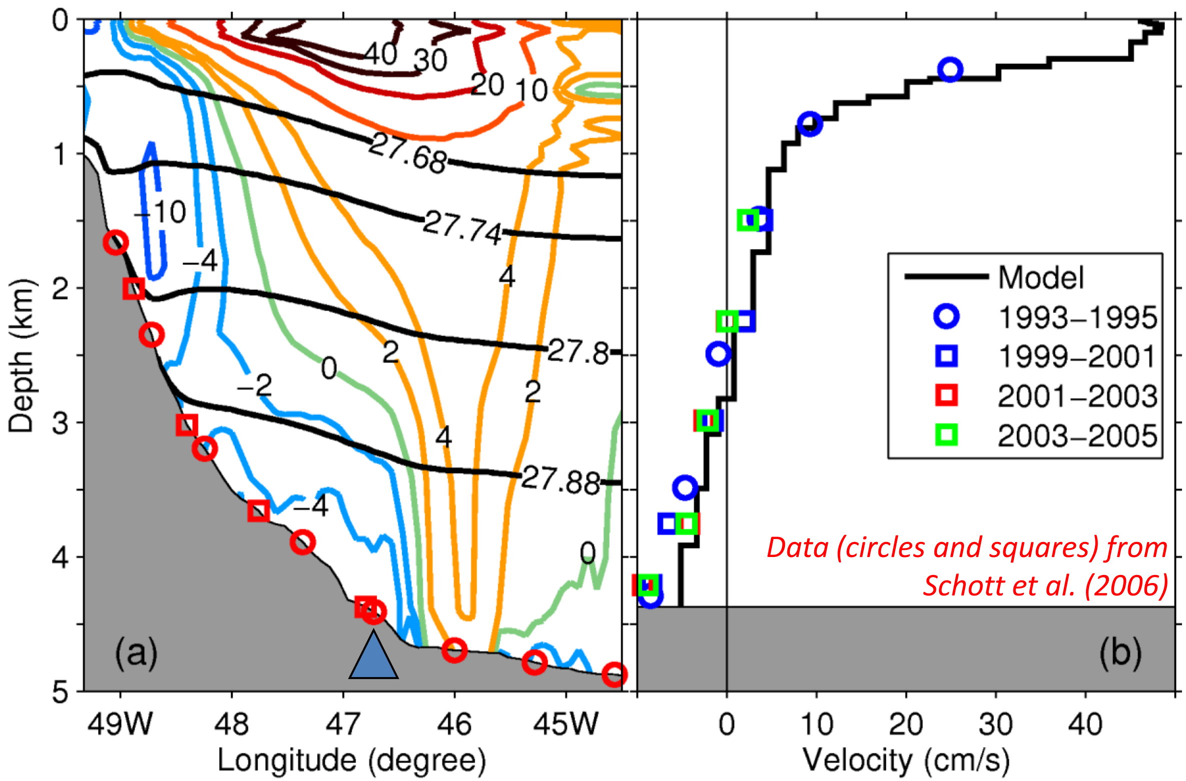
Comparison near 53N



Moored observations from Fischer et al., 2004, 2010. HYCOM results and comparison to observations see Xu et al., 2013

Comparison near 43N



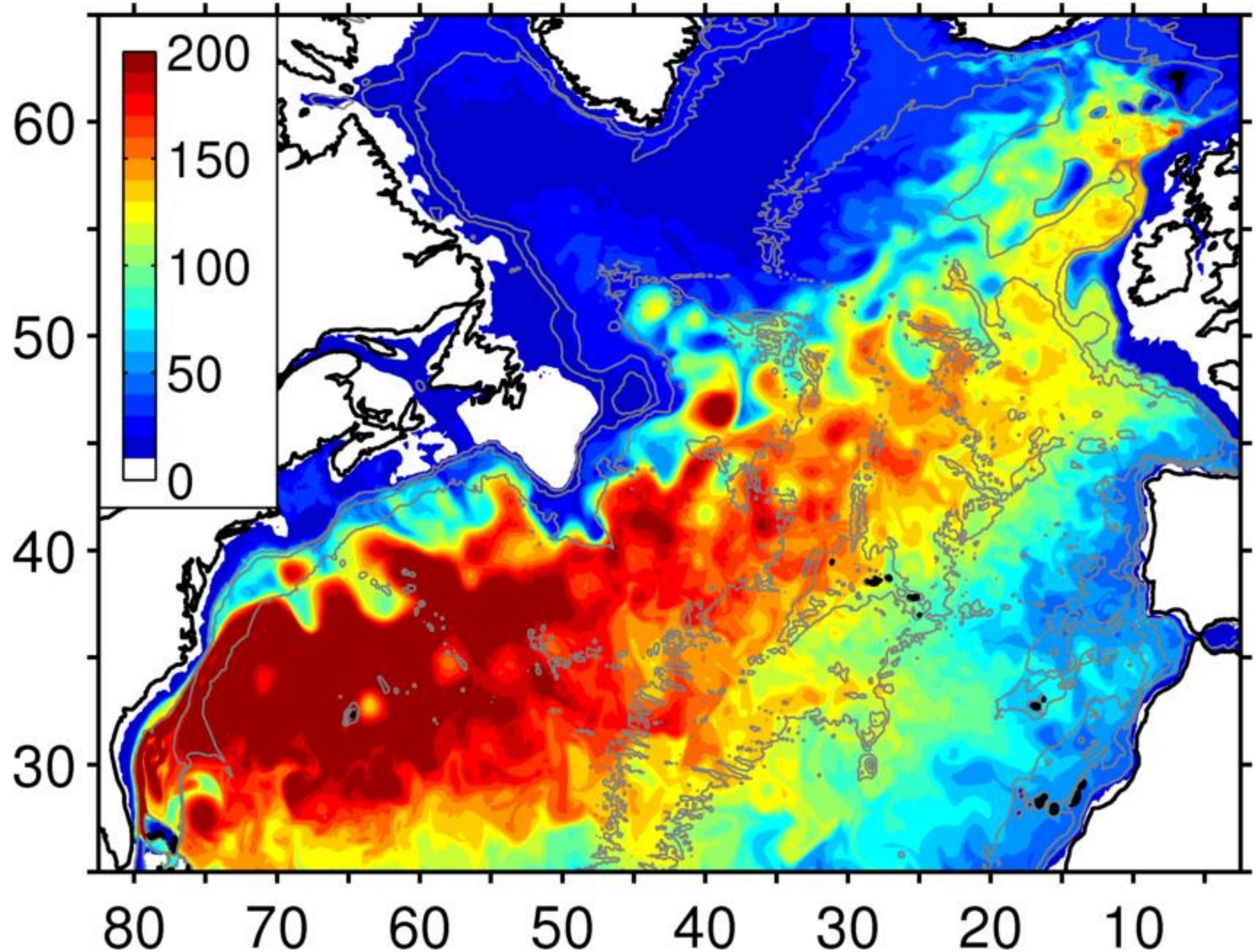


Moored observations from Clarke et al., 1998; Meinen 2000; Schott et al., 2004, 2006. Model results and comparison to observations see Xu et al., 2013

Tracer in the Atlantic Simulation

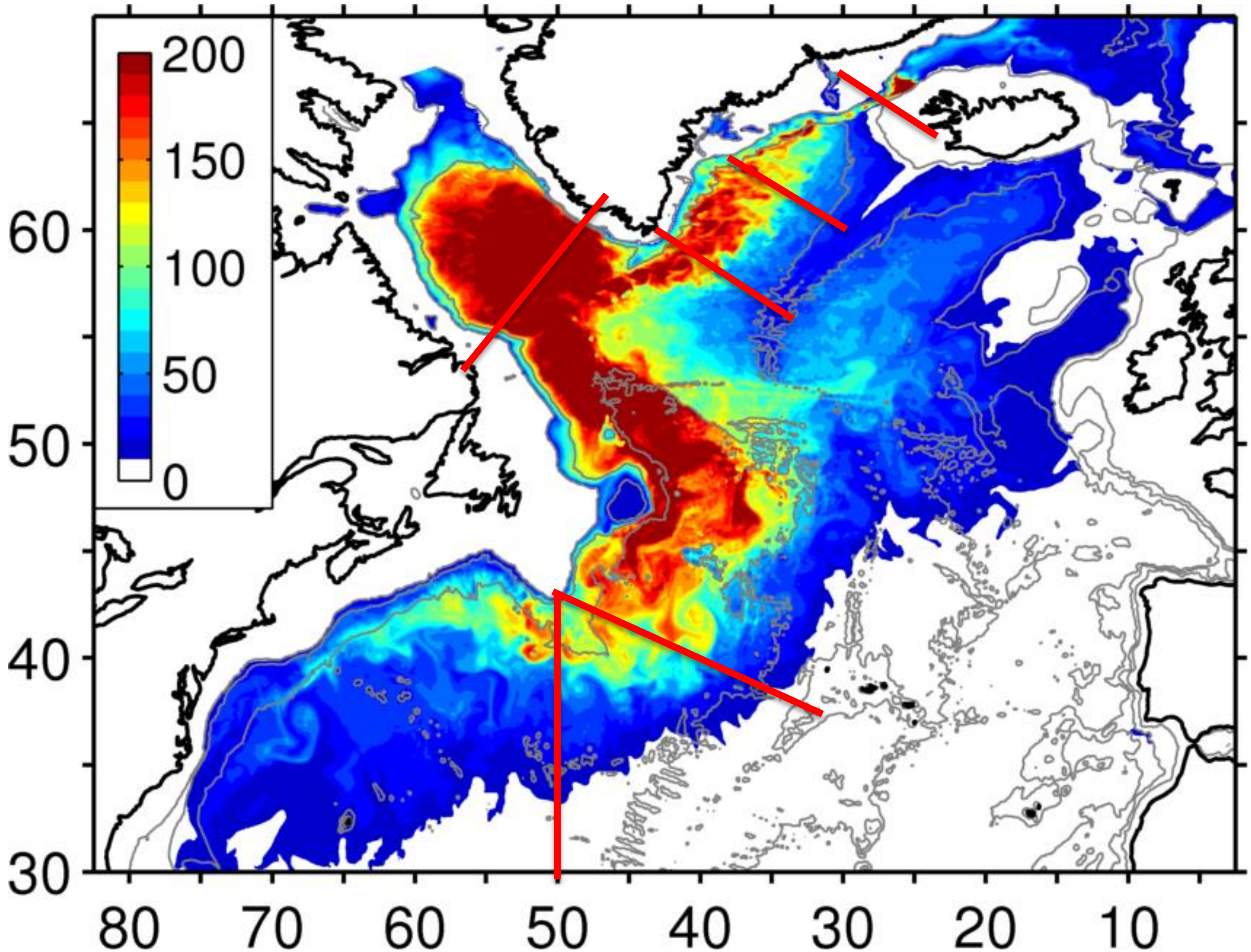
- HYbrid Coordinate Ocean Model (HYCOM, Bleck, 2002; Chassignet et al., 2003; http://www.hycom.org); see Xu et al., 2010, 2012, 2013 for documentation of the Atlantic model results
- Model domain extends meridionally from 28° S to 80° N, as a subset of the global prediction system developed at NRL/SSC
- 0.08° horizontal resolution (5-6 km in the SPNA); 32 σ_2 layers in vertical, with thermo-baric effect parameterized
- Initialization with zero velocity and January potential temperature and salinity from monthly ocean climatology GDEM (Carnes, 2009)
- Climatolgical forcing (E026): 25-year spin-up using forcing based on a monthly climatology (ERA40, Uppala et al., 2005) + submonthly wind anomalies from Navy Operational Global Atmospheric Prediction System (NOGAPS) for year 2003;
- Tracers were injected on Jan 1 of model year 16 (at the Denmark Strait sill below model layer 21 and in the Florida Strait in the top 15 layers). The simulation is integrated for 10 years.

10 years after (Florida Strait)



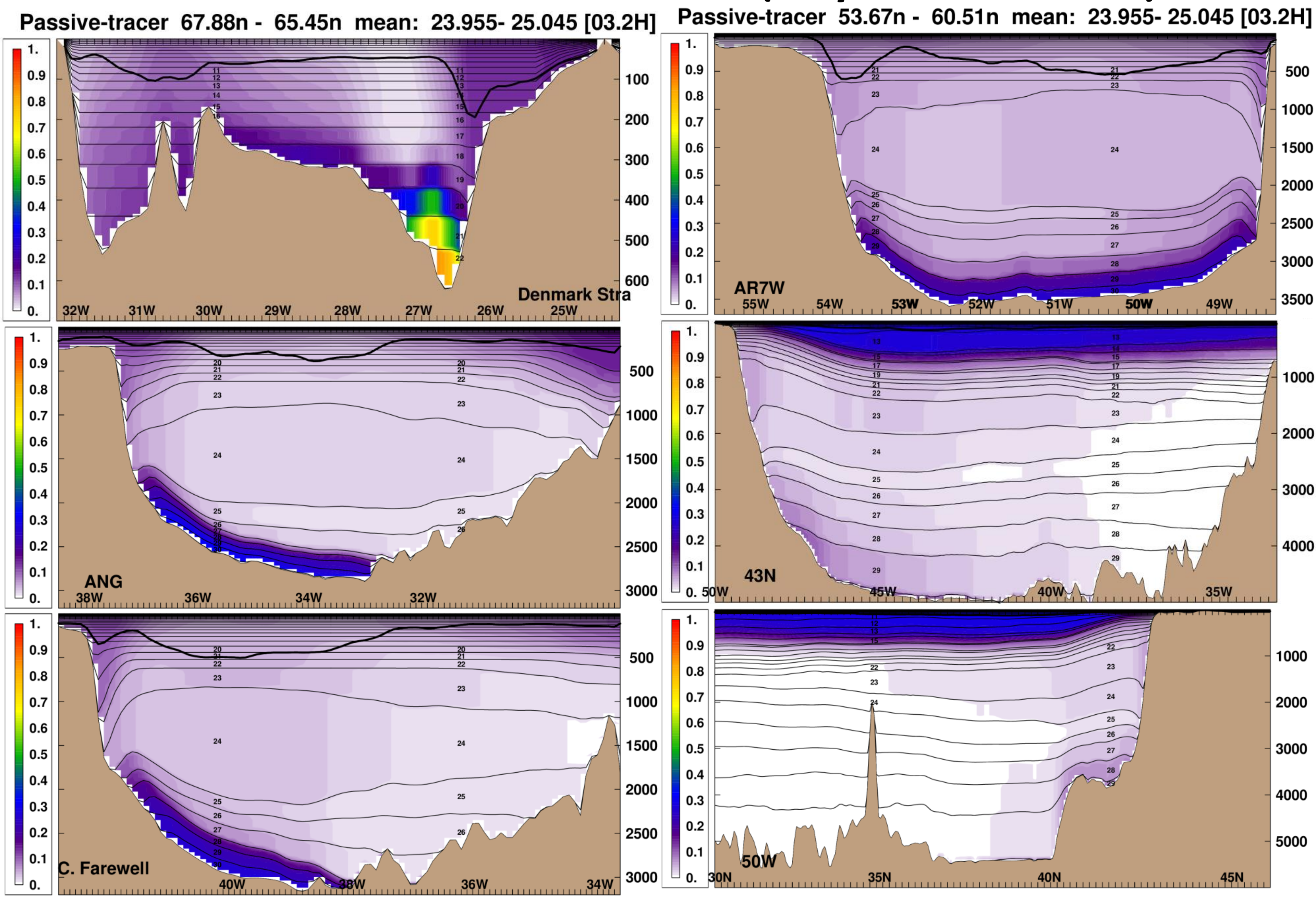
Integrated tracer content below model layers at the end of the simulation;

10 years after (Demark Strait)

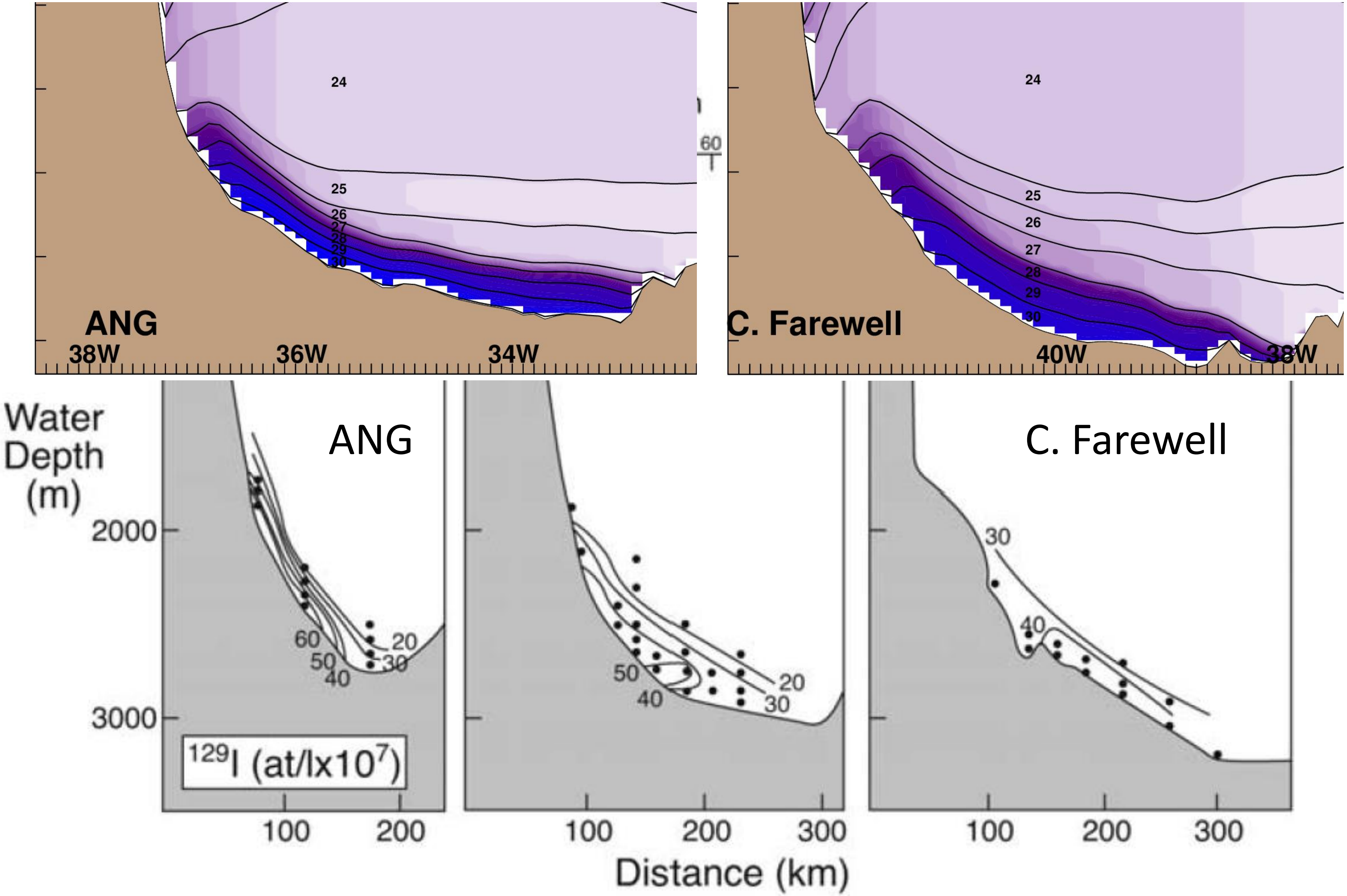


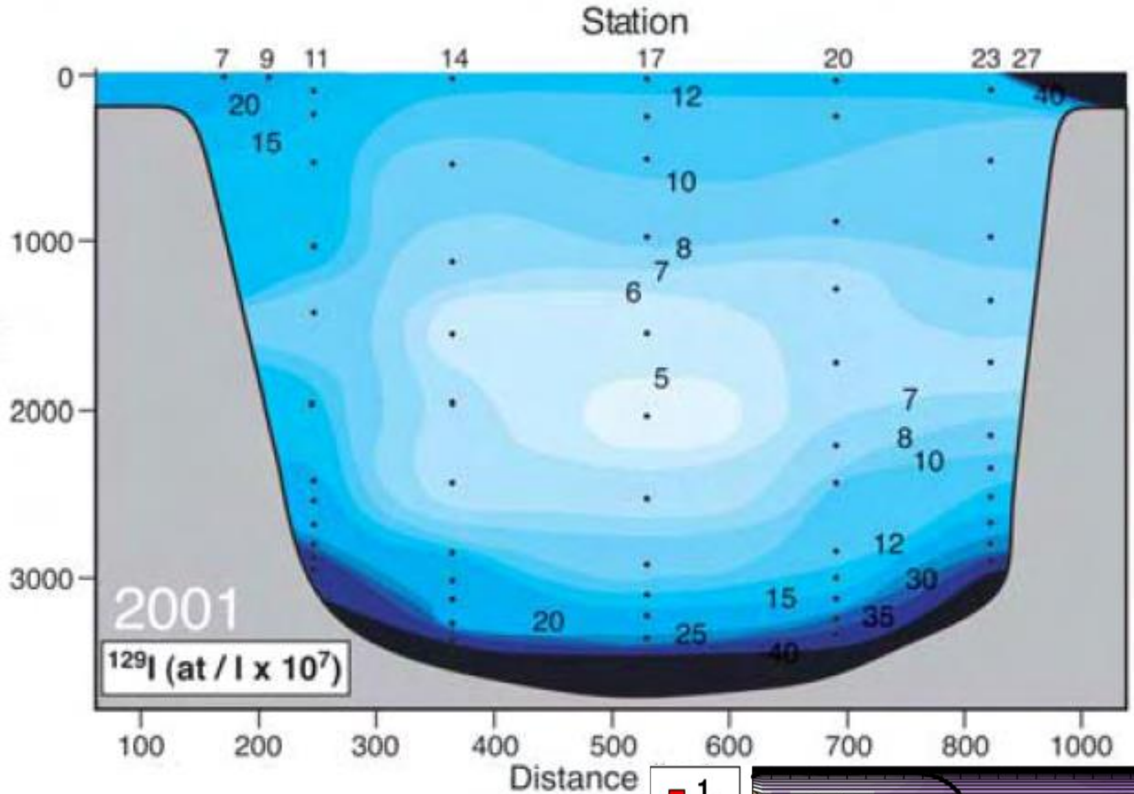
Integrated tracer content below model layer 20 at the end of the simulation;

Vertical distribution (1 year mean)



Compared to the observed I^{129}

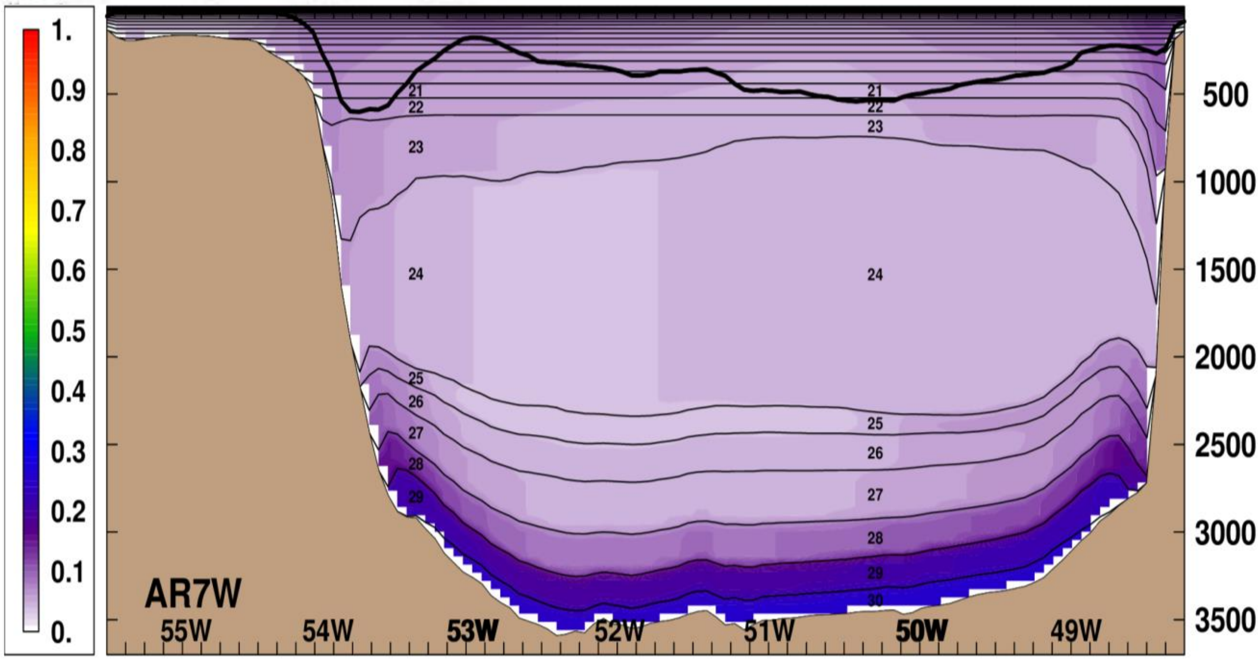




In the Labrador Sea

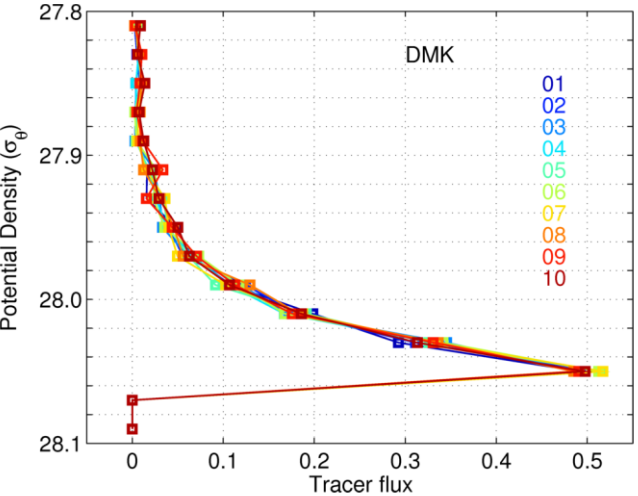
I129 from Smith et al., 2005

Both the observed I^{129} and numerical tracer spread out the lowest part of *entire* Labrador Sea.



Vertical structure of tracer flux

Denark Strait



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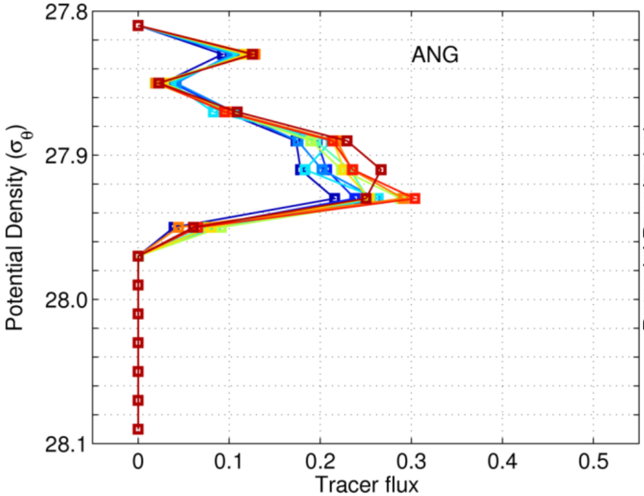
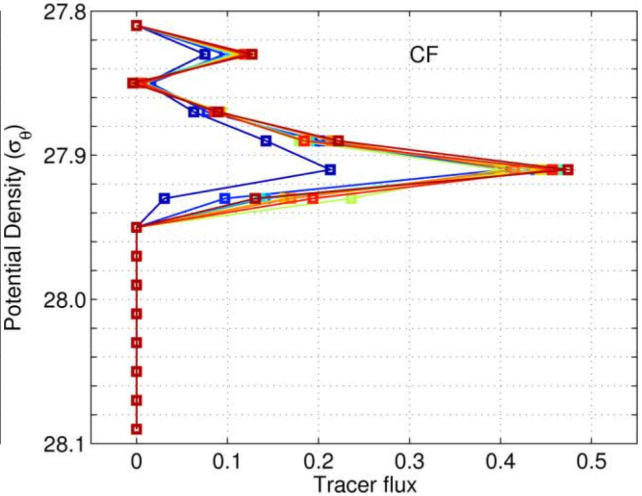
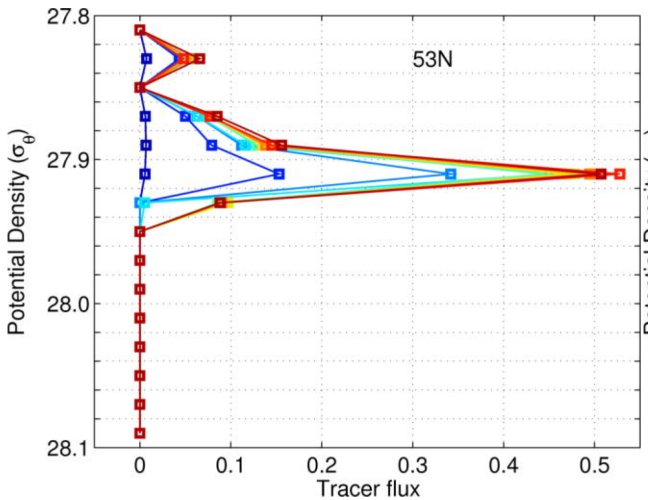


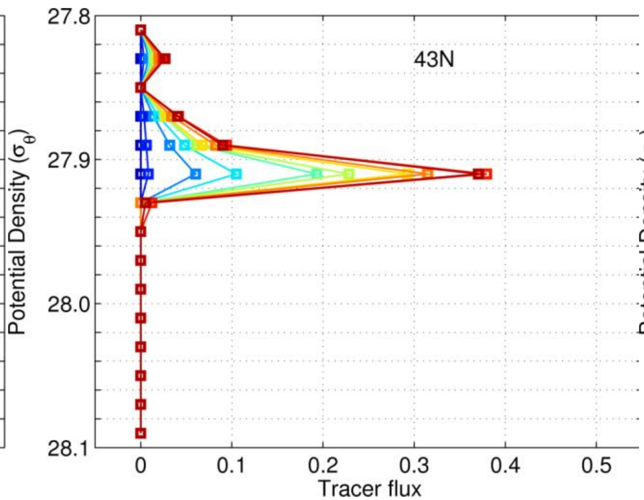
Cape Farewell



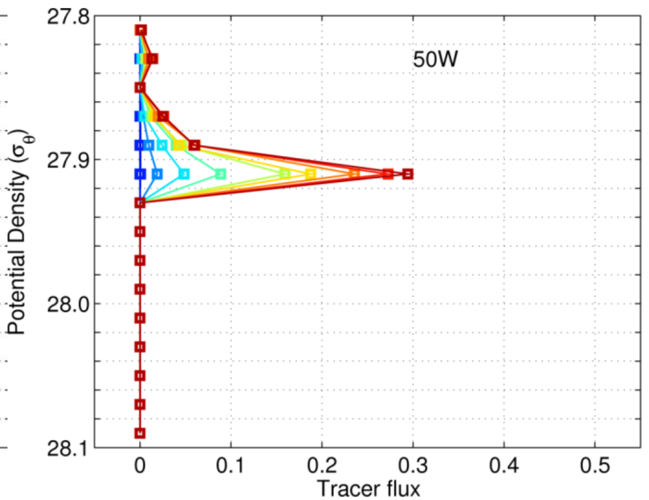
Labrador Sea



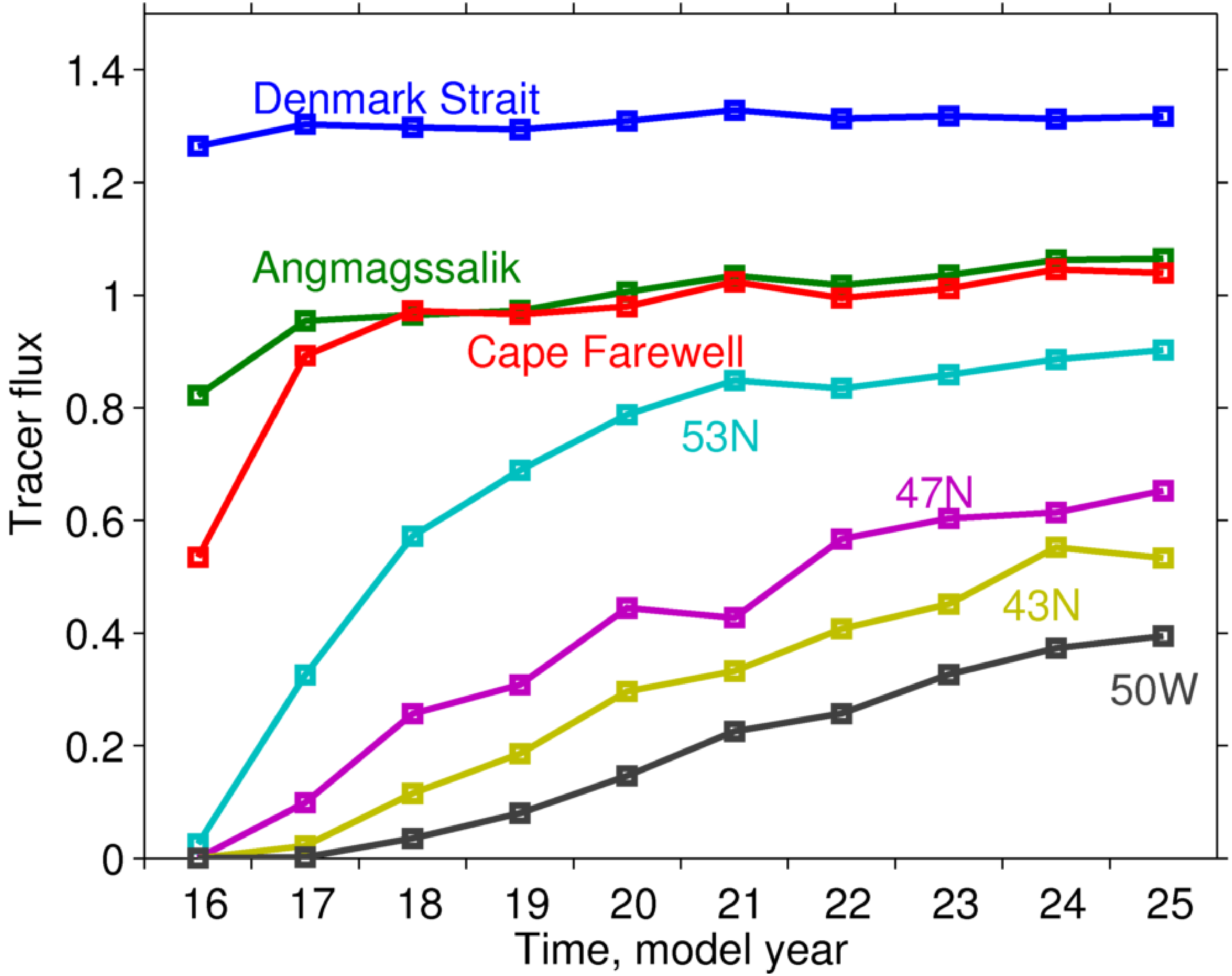
Grand Banks



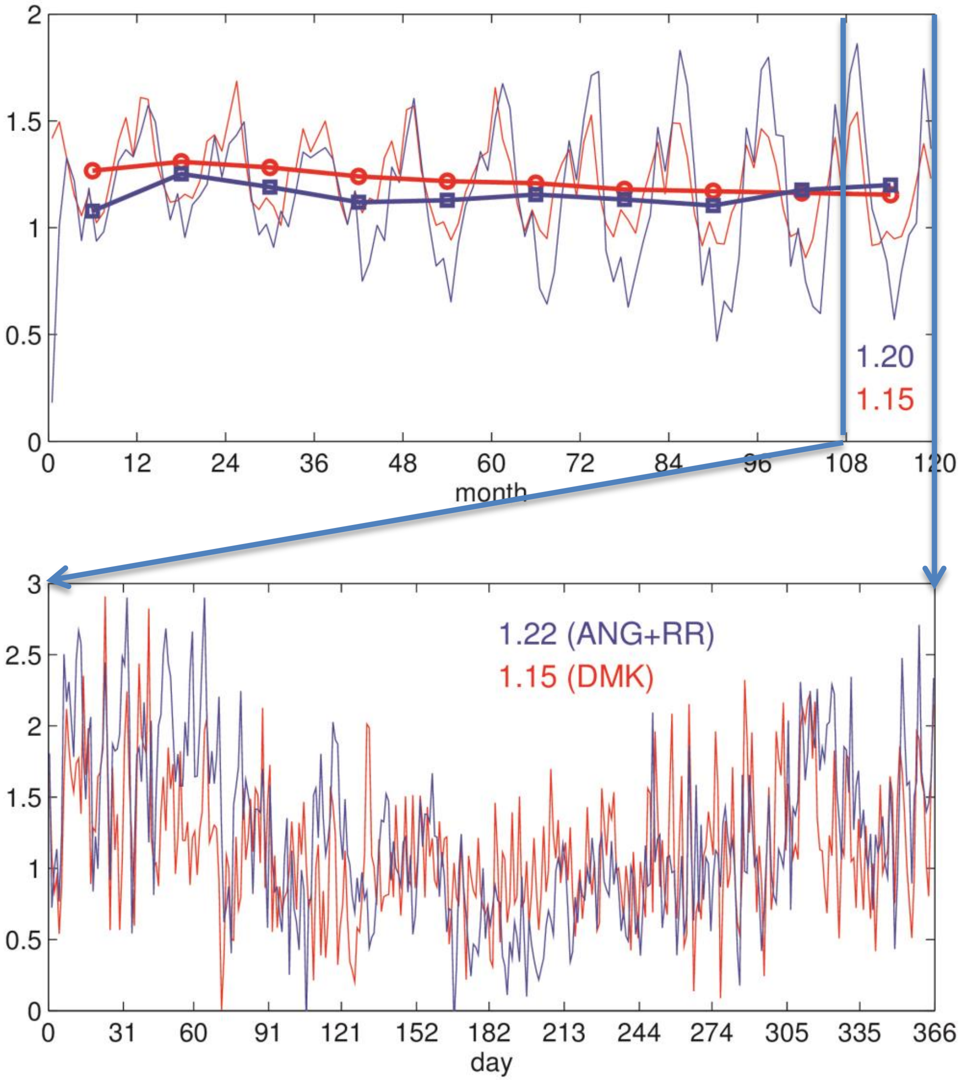
50W

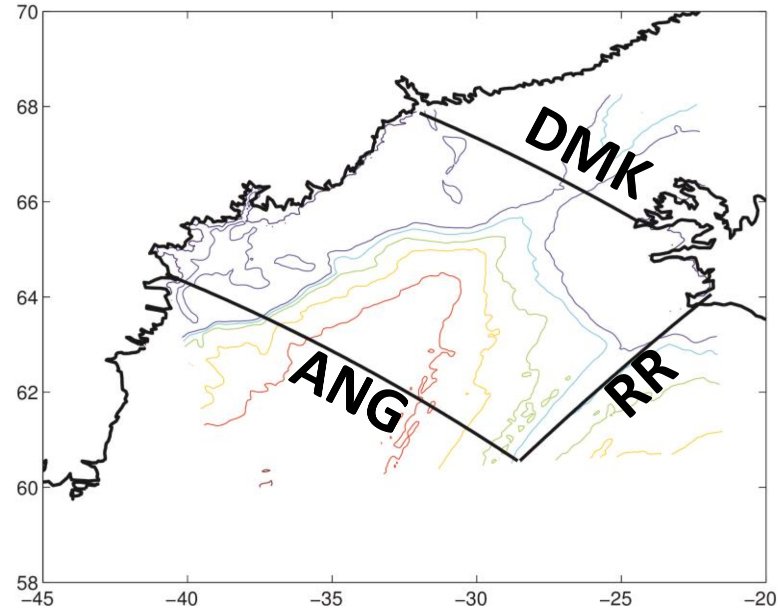


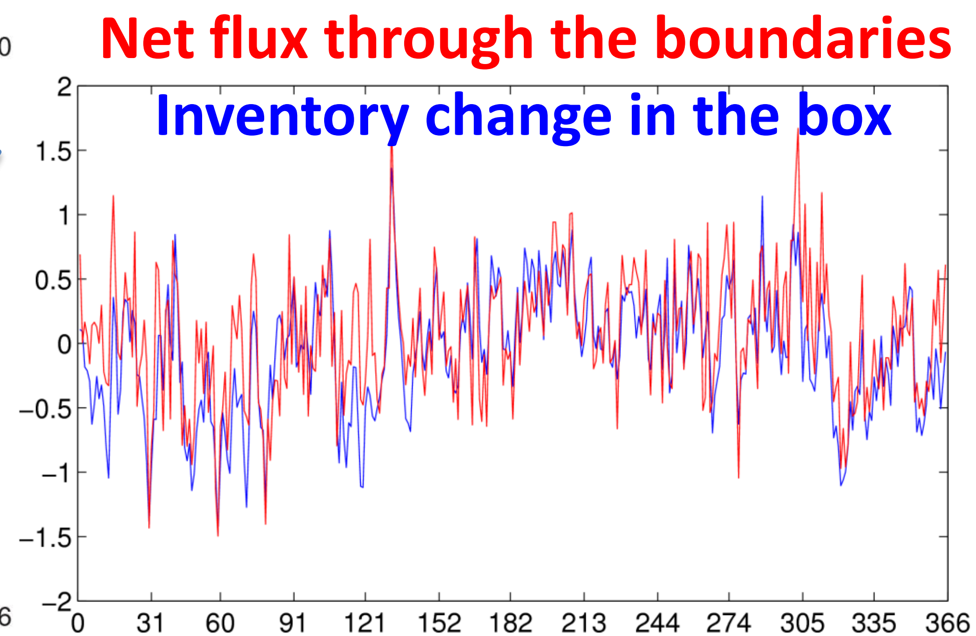
Total tracer fluxes in overflow water



Full water column budget



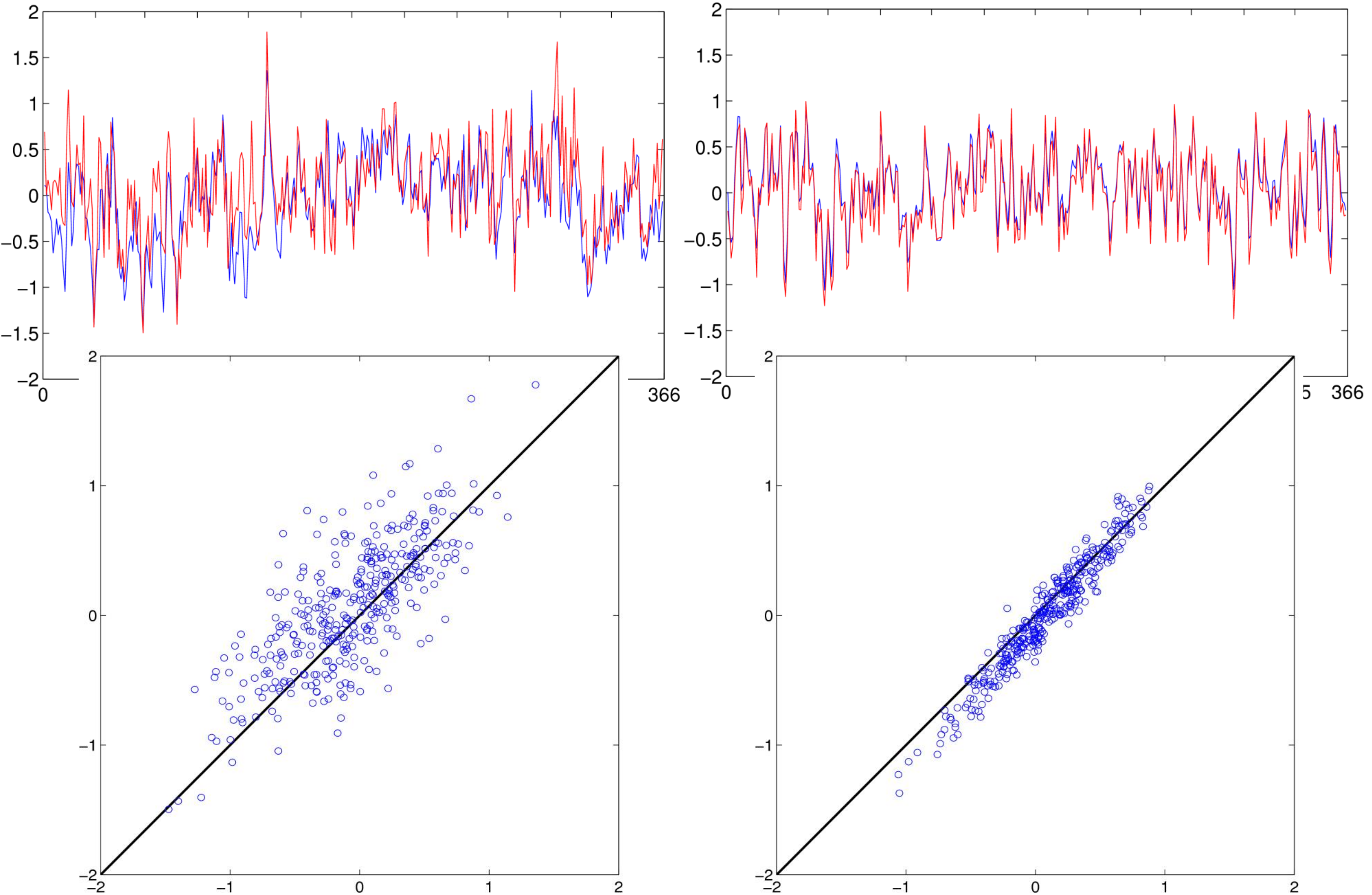




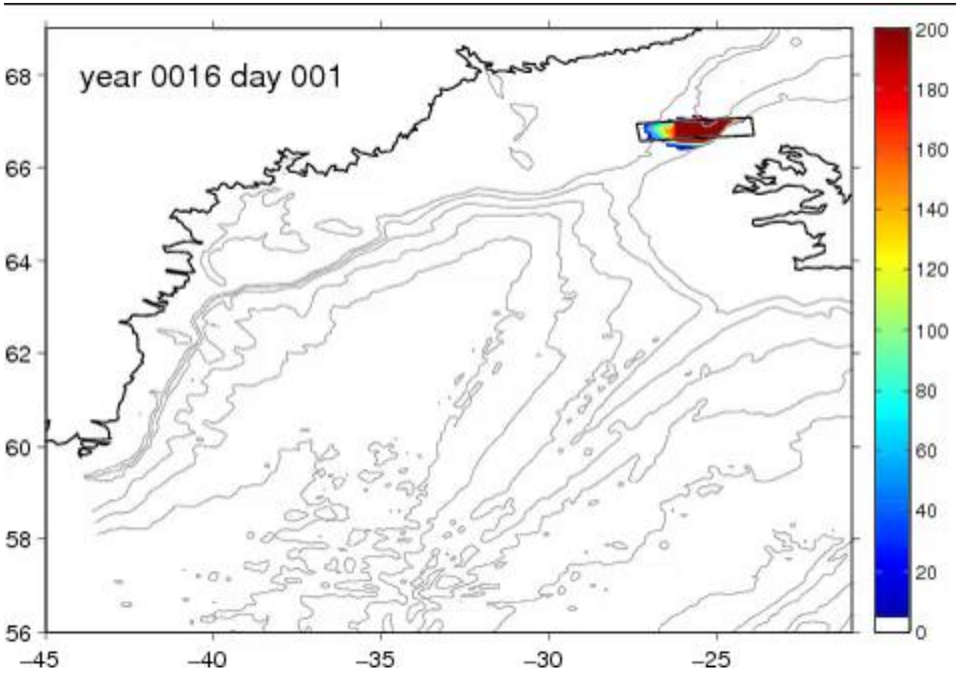
Summary

- A numerical tracer experiment is conducted in an eddy-resolving Atlantic simulation.
- The DSOW tracer is seen descend from the Denmark Sill to the observed DSOW depth range in the Irminger and Labrador Sea, with a vertical distribution similar to the observed I^{129}.
- Preliminary analysis suggest that immediately after the DSOW spreading into the Irminger Sea, some tracer have been *lost* to water above the overflow.
- The full water column budget of the tracer flux/content is *approximately* conserved.
- **currently on going ** simplify the experiment by releasing tracer only in the DSOW, and save the model fluxes to test the conservation of tracer content.

If I saved the model volume fluxes …



Thank you



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